Bat Surveys on USFS Northern Region Lands in Montana: 2005

Prepared for:

USDA Forest Service, Northern Region
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Montana Natural Heritage Program
Natural Resource Information System
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December 2005

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P.O. Box 6779
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Agreement Number:

05-CS-11015600-033

By:

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This document should be cited as follows:
Hendricks, P. and B.A. Maxell. 2005. Bat Surveys on USFS Northern Region Lands in Montana: 2005. Report to the USDA Forest Service, Northern Region. Montana Natural Heritage Program, Helena, MT. 12 pp. plus appendices.

Executive Summary

The distribution and status of bats in Montana remain poorly documented on US Forest Service Northern Region lands. This is of conservation interest because management activities on Forest Service lands (e.g., timber harvest, mine closures, closures of historic buildings) may have unintended consequences on habitats bats use for roosting and foraging and may therefore negatively impact bat populations. Additionally, the Northern Region has designated Townsend's Big-eared Bat (*Corynorhinus townsendii*) a Species of Concern requiring special attention; it is widespread but infrequently captured in Montana, with few documented hibernacula and maternity roosts and a reputation for being highly susceptible to human disturbance at roost sites.

The Northern Region recognized the need for additional documentation of bats on Forest Service lands to address inventory and monitoring requirements, and initiated bat surveys in 2005 across the Region on selected National Forest (NF) Ranger Districts (RD). In Montana, these included Swan Lake RD-Flathead NF, Bozeman RD-Gallatin NF, Townsend RD-Helena NF, Libby RD-Kootenai NF, and Judith RD-Lewis & Clark NF. Following a modified protocol based on the Oregon Bat Grid system, crews surveyed non-randomly chosen suitable habitats within randomly chosen 10 x 10 km^2 sample units in each RD; ten sites (often two/sample unit) on each District were sampled, for a total of 50 sites surveyed on Northern Region lands in Montana. Thus, this approach is primarily targeted at identifying species richness within grid cells; inferences on rates of occupancy are limited to the percent of 10 x 10 km^2 grid cells where a species was detected within each sampled RD.

Eleven species of bats, represented by 795 total individuals, were captured during late-June to mid-August 2005. Species captured included Townsend's Big-eared Bat at two sites, Big Brown Bat (*Eptesicus fuscus*) at 14 sites, Hoary Bat (*Lasiurus cinereus*) at 20 sites, Silver-haired Bat (*Lasionycteris noctivagans*) at 25 sites, California Myotis *(Myotis californicus*) at nine sites, Western Small-footed Myotis (*M. ciliolabrum*) at eight sites, Western Long-eared Myotis (*M. evotis*) at 26 sites, Little Brown Myotis (*M. lucifugus*) at 32 sites, Fringed Myotis (*M. thysanodes*) at four sites, Long-legged Myotis (*M. volans*) at 23 sites, and Yuma Myotis (*M. yumanensis*) at two sites. No bats were captured at five of the sites sampled, although presence of bats was noted at each.

The 2005 field survey filled important gaps in documented distributions in Montana, adding several new county records and underscoring the need for additional survey effort to define bat distributions on USFS landscapes more fully. A summary of all existing bat records across the region clearly shows large distribution gaps for all species, further underscoring the need for addition surveys. In particular, large portions of the Beaverhead-Deerlodge NF, Custer NF, Flathead NF, Gallatin NF, and Lewis and Clark NF lack records for any bat species. We recommend that the USFS Northern Region continue with a grid-based random sampling scheme stratified by ecoregion or Ranger District, resulting in a site-occupancy approach that allows for valid inference of presence across the selected stratum. A grid-based sampling scheme is an important monitoring approach that should be extended beyond USFS lands and coordinated with other partner agencies and organizations to guide effective bat management across the state.

Acknowledgments

We thank Fred Samson and Jenny Taylor (USFS) for initiating and promoting the project, through the USFS Regional Inventory and Monitoring (RIM) program, and overseeing its implementation. Jenny also organized the excellent training session, run by Pat Ormsbee (USFS) and Dr. Joe Szewczak (Humboldt State University); Kristi Dubois (MTFWP) helped coordinate the training by arranging a home base in the FWP Region Office in Missoula. Pat and Jenny developed the sampling grid that guided surveys. Actual on-the-ground surveys on the Helena, Gallatin, and Lewis & Clark National Forests were conducted by Cori Lausen and Erin Baerwald, with the assistance of Shawna Campbell (Helena NF), Marion Cherry (Gallatin NF), Eric Tomasik (Lewis & Clark NF), Trixi Smith, and Bryce Maxell (MTNHP). Flathead and Kootenai National Forests surveys were conducted by Paul Hendricks (MTNHP), with the assistance of Jane Ingebretson (Flathead NF), Jenny Holifield (Kootenai NF), Henning Stabins (Plum Creek), and Scott Tomson (Lolo NF). Scott Blum (MTHNP) entered survey data into the Montana Natural Heritage Program's POD database, facilitating the production of new distribution maps and the updating of element occurrence data in the Montana Natural Heritage Program's Biotics database.

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INTRODUCTION

There has been growing concern in recent decades regarding the status of bats throughout North America, partly because of a general lack of basic natural history information (Hayes 2003), and also because a variety of habitats traditionally used by bats for roosting and foraging have been subjected to widespread disturbance, alteration, reduced availability, or complete removal (Fenton 1997, Pierson 1998). As a result, six species or subspecies of bats in the continental United States currently are classified as endangered under the United States Endangered Species Act of 1973 (O'Shea et al. 2003); none of these bats occur in Montana.

Conservation and protection of roosts are important long-term management activities for many North American bat species (Sheffield et al. 1992). Unfortunately, conservation efforts for bats in Montana are often hampered by a lack of data on their habitat requirements. For example, the little data available from Montana on foraging and diet of bats have been obtained largely at water sources (Jones et al. 1973), with no knowledge of where the foraging bats are roosting. Conversely, studies of bat roosts in Montana (e.g., Worthington 1991a, 1991b, Hendricks et al. 2000, 2004) lack information on where and how far the roost members go to feed and drink. Nor have patterns of roost selection and fidelity (e.g., Sherwin et al. 2003) been studied in Montana, even though it is understood that suitable summer and winter roosts may limit the local and regional distribution and abundance of many temperate-zone bats (Humphrey 1975, Dobkin et al. 1995), especially cave- and crevice-dwelling taxa.

Most bat species use a variety of localized habitats for roosting, be they natural sites (e.g., caves, trees, rock crevices) or man-made sites (e.g., buildings, mines, bridges). Sites may be used only during specific seasons of the year, and then for different purposes. Recent research on bat roosts in Montana has followed the national pattern of inventorying and monitoring roosts in caves and abandoned mines (e.g., Worthington 1991a, 1991b, Hendricks et al. 2000, 2004; Hendricks and Kampwerth 2001), and this remains an important activity for a state bat conservation plan. Nevertheless, sampling bats across the landscape at foraging sites continues to be critical for filling gaps in documented distribution, assessing relative abundance of local populations, and ultimately identifying roosts for these populations.

Distribution and status of bats remain poorly documented on US Forest Service Northern Region lands in Montana. A summary of all existing bat records across the region clearly shows large distribution gaps for all species, further underscoring the need for addition surveys. In particular, large portions of the Beaverhead-Deerlodge NF, Custer NF, Flathead NF, Gallatin NF, and Lewis and Clark NF lack records for any bat species. This is of conservation interest because management activities on Forest Service landscapes may have unintended consequences affecting bat populations and the habitats bats use for roosting and foraging. The Northern Region recognized the need for additional documentation of bats on Forest Service lands to address inventory and monitoring requirements, and therefore initiated bat surveys in 2005 across the Region on selected National Forest Ranger Districts. Additionally, Townsend's Big-eared Bat (*Corynorhinus townsendii*), a G4 S2 state Species of Concern in Montana (see Appendix A for codes), is a Northern Region Species of Concern requiring special management attention because of few documented hibernacula and maternity roosts and a reputation for being highly susceptible to human disturbance at roost sites (Pierson et al. 1999).

METHODS

The primary objective of the 2005 survey was to document bat species richness (number of species) within sample units, with a longer-term objective of inferring sample unit occupancy by each species across entire Ranger Districts. Surveys for bats in Montana were conducted during summer (late-June to mid-August) 2005 on one Ranger District (RD) in each of five National Forests (NF) of the Northern Region: Flathead NF-Swan Lake RD, Gallatin NF-Bozeman RD, Helena NF-Townsend RD, Kootenai NF-Libby RD, Lewis & Clark NF-Judith RD. The sampled Flathead and Kootenai RDs are in northwestern Montana west of the Continental Divide. Sampled RDs for the other three Forests are in west-central and central Montana east of the Continental Divide. Survey sites spanned a range of elevations: 1990-5030 ft west of the Divide and 4533-7642 ft east of the Divide.

The Oregon Bat Grid was used as a framework from which to draw randomly-selected grid cells for survey in the 2005 Northern Region surveys. A grid of square blocks, each 10 km on a side (100 km^2 in area), was created and overlaid on each RD, to create a target population of grid cells to infer occupancy rates. Each grid cell equaled a sample unit. Sample units were selected using randomly generated numbers; sample units to be surveyed were those with the lowest numbers and with reasonable access to potential survey sites. Five sample units per RD were to be surveyed at two distinct locations for one night each. This differs dramatically in survey effort from the Oregon Bat Grid (draft protocols available from Pat Ormsbee), which calls for up to a total of 12 surveys in a sample unit, or until all species expected to occur in a sample unit have been detected. For the 2005 Northern Region Inventory, each RD received ten nights of survey effort, resulting in a total of 50 sites surveyed on Northern Region lands (Appendix 2). Only one, two and three sample units received two nights of survey effort on the Gallatin, Helena, and Lewis & Clark, respectively; the remaining nights of survey effort on those Forests were spent in single surveys of additional sample units.

Sites chosen for survey within a sample unit were determined in the field by survey crews or using information provided by other Forest Service personnel. Sites were usually features that might concentrate bat activity, most often water sources such as ponds and streams, less often bridges over streams, and caves and mines, and least often at abandoned buildings. Bats were captured using mist nets of various lengths and configurations, sometimes in conjunction with harp traps; number of nets deployed varied from site to site. Nets were to be deployed at twilight and left open for 3.5 hours, weather permitting, or until 1 hour passed with acoustic detections.

Species identification was based on published keys and species accounts (van Zyll de Jong 1985, Nagorsen and Brigham 1993, Adams 2003) and a key developed specifically for this project. Standard measurements (weight, forearm length, ear length, sex, age, reproductive status) were obtained from each individual. Wing punch tissue samples were also collected from each captured bat, until five punches/species were accumulated from each site. Tissue was taken using sterile procedures and stored in biopsy tubes containing desiccant. Tissues are to be used for genetic identification of species pairs that are difficult to distinguish in the field (especially *Myotis lucifugus* and *M. yumanensis*). Genetic analysis had not been initiated at the time of this report.

The survey protocol also called for acoustic monitoring at each site using a Pettersson 240x detector or, in its absence, a Titley Anabat II detector. Calls were to be captured and analyzed using the appropriate software (SONOBAT or ANABAT). Unfortunately, equipment often malfunctioned or was not available until late in the field season. The number of calls captured, analyzed, and used for species-specific determination were too few to include in this report. However, we feel acoustic sampling is an important component of all future inventory and monitoring efforts (see Hayes 1997 and O'Farrell and Gannon 1999 for examples).

Data was recorded on standardized data sheets, and later transcribed to the Point Observation Database housed at the Montana Natural Heritage Program, Helena, where it is available for agency and public use. Statistical analyses follow procedures in Sokal and Rohlf (1981).

Results

Species and Numbers Captured

During summer 2005, 50 sites were sampled for bats on USFS Northern Region lands in Montana: 20 sites west and 30 sites east of the Continental Divide (see map in Appendix C). Bats were detected at all sites and captured at 90% of these (see Appendix B). Eleven species were captured, represented by 795 individuals (Table 1); of these species, Townsend's Big-eared Bat (G4 S2) and Fringed Myotis (G4G5 S3) are Montana Animal Species of Concern (Montana Natural Heritage Program 2004). Nine species were captured at sites west and ten species at sites east of the Continental Divide. The California Myotis was captured only west of the Divide, Townsend's Big-eared Bat and Western Small-footed Myotis were captured only east of the Divide.

Most frequently captured in the total sample was the Little Brown Myotis, representing 35.8% of all captures from 64% of the survey sites (Table 1). Second most frequently captured was the Silver-haired Bat, representing an additional 22% of all captures from half of the survey sites. Hoary Bat, Western Long-eared Myotis, and Long-legged Myotis accounted for 8.8-10.7% of the total individuals captured, at 40-52% of the survey sites. Big Brown Bat represented 6.7% of the total captures from 28% of the survey sites. The remaining five species each accounted for <3% of the total captures, and were found at 4% to 18% of the survey sites. Hoary Bat was visually identified at three sites west of the Continental Divide (one site on the Flathead NF, two sites on the Kootenai NF) where it was not captured; its large size and early emergence made this species identifiable in flight.

Table 1. Number of sites where bats were captured, and total number of individuals captured, on five Region 1 National Forests in Montana, 24 June-18 August, 2005. Ten sites were sampled per Forest, each site for one night. Species and number of captures for each site are listed in Appendix 2.

Species[a]	**Forest**					**Total**
	Flathead	**Kootenai**	**Helena**	**Gallatin**	**Lewis & Clark**	
COTO	0, 0[b]	0, 0	2, 9	0, 0	0, 0	2, 9
EPFU	0, 0	2, 5	3, 4	4, 13	5, 31	14, 53
LACI	0 (1v), 0	3 (2v), 5	3, 7	5, 29	9, 44	20 (3v), 85
LANO	0, 0	5, 11	4, 22	6, 33	10, 109	25, 175
MYCA	4, 4	5, 10	0, 0	0, 0	0, 0	9, 14
MYCI	0, 0	0, 0	3, 14	1, 1	4, 6	8, 21
MYEV	3, 3	3, 7	8, 17	5, 32	7, 16	26, 75
MYLU	4, 11	7, 33	4, 12	10, 176	7, 53	32, 285
MYTH	0, 0	2, 2	2, 4	0, 0	0, 0	4, 6
MYVO	4, 9	3, 4	5, 13	4, 16	7, 28	23, 70
MYYU	0, 0	1, 1	1, 1	0, 0	0, 0	2, 2
Total captures	27	78	103	300	287	795
Species Richness	4 (+1v=5)	9	10	7	7	11

[a] Species codes: COTO (*Corynorhinus townsendii*, Townsend's Big-eared Bat), EPFU (*Eptesicus fuscus*, Big Brown Bat), LACI (*Lasiurus cinereus*, Hoary Bat), LANO (*Lasionycteris noctivagans*), MYCA (*Myotis californicus*, California Myotis), MYCI (*Myotis ciliolabrum*, Western Small-footed Myotis), MYEV (*Myotis evotis*, Western Long-eared Myotis), MYLU (*Myotis lucifugus*, Little Brown Myotis), MYTH (*Myotis thysanodes*, Fringed Myotis), MYVO (*Myotis volans*, Long-legged Myotis), MYYU (*Myotis yumanensis*, Yuma Myotis).

[b] Number of sites, number of individuals; v = sites with good visual observation but no capture.

New County Records

The summer 2005 Northern Region survey resulted in new county records for nine species (see maps in Appendix C): Big Brown Bat (Gallatin), Hoary Bat (Judith Basin), Silver-haired Bat (Broadwater), California Myotis (Lake, Missoula), Western Small-footed Myotis (Gallatin), Western Long-eared Myotis (Gallatin), Fringed Myotis (Lincoln), Long-legged Myotis (Gallatin), and Yuma Myotis (Lincoln). Gallatin County (Gallatin NF) received the most new records, with the addition of four species. Additional bat inventory work conducted in 2003-2005 by the Montana Natural Heritage Program in eastern Montana resulted in numerous additional county records for these and other species.

Evidence of Reproduction by Females

The best evidence of reproduction by a particular bat species on a Forest is the presence of pregnant and lactating females. Testicular males are reproductively active, but their presence in a sample does not necessarily indicate reproduction near the survey site, while post-lactating females and volant juveniles may have dispersed from adjacent areas.

Pregnant or lactating females were identified in seven of nine species captured west of the Continental Divide; these included all *Myotis* species on the Flathead NF, with the addition of Yuma Myotis, Big Brown Bat, and Silver-haired Bat from the Kootenai NF. Only Hoary Bat and Fringed Myotis lacked evidence of reproduction on the two western Forests. East of the Divide, pregnant or lactating females were identified in seven of ten species captured; only Western Small-footed Myotis, Yuma Myotis, and Big Brown Bat lacked evidence of reproduction in samples of captured females. However, we expect reproduction by females of all species will be documented in the future with additional survey effort.

Adult Sex Ratios

Adult males were caught more often than adult females, as represented in pooled samples for the majority of species (six of seven) from east of the Continental Divide, and where sample sizes exceeded 20 individuals per species (Table 2). Of these, significantly more males were present in samples of Big Brown Bat, Hoary Bat, Western Small-footed Myotis, and Little Brown Myotis. Sample sizes of all species west of the Continental Divide, except Little Brown Myotis, were too small for statistical analysis. For this species, as with samples from east of the Divide, significantly more males were captured (chi squared = 4.85, P = 0.028).

Table 2. Adult sex ratios (number of males: number of females) of bats captured on five Region 1 National Forests (one District each) in Montana, 24 June-18 August, 2005.

Species[a]	**Forest**					**χ^2 value**[b]
	Flathead	**Kootenai**	**Helena**	**Gallatin**	**Lewis & Clark**	
COTO	---	---	1:8	---	---	---
EPFU	---	2:3	4:0	11:2	29:2	18.20**
LACI	---	5:0	4:0	23:4	37:7	19.92**
LANO	---	5:6	10:12	22:11	53:56	NS
MYCA	2:2	3:7	---	---	---	---
MYCI	---	---	13:1	1:0	6:0	8.50*
MYEV	2:1	4:3	3:14	17:15	10:5	NS
MYLU	5:6	28:5	12:0	147:26	51:1	81.11**
MYTH	---	1:1	1:3	---	---	---
MYVO	4:5	4:0	5:8	9:6	21:7	NS
MYYU	---	0:1	1:0	---	---	---

[a] Species codes: COTO (*Corynorhinus townsendii*, Townsend's Big-eared Bat), EPFU (*Eptesicus fuscus*, Big Brown Bat), LACI (*Lasiurus cinereus*, Hoary Bat), LANO (*Lasionycteris noctivagans*), MYCA (*Myotis californicus*, California Myotis), MYCI (*Myotis ciliolabrum*, Western Small-footed Myotis), MYEV (*Myotis evotis*, Western Long-eared Myotis), MYLU (*Myotis lucifugus*, Little Brown Myotis), MYTH (*Myotis thysanodes*, Fringed Myotis), MYVO (*Myotis volans*, Long-legged Myotis), MYYU (*Myotis yumanensis*, Yuma Myotis).

[b] Tests the null assumption of equal numbers of males and females captured. Applies only to Forests (Helena, Gallatin, Lewis & Clark) where Districts surveyed are east of the Continental Divide and species sample size > 20 for the combined Districts. All chi squared values are Yates corrected: NS = not significant at á = 0.05, * $P < 0.01$, ** $P < 0.0001$.

Discussion

Overview

The summer 2005 survey helped fill distribution gaps, produced several new county records (Appendix C), and provided evidence that several species of bats are using landscapes under Northern Region stewardship for reproductive activities, including Townsend's Big-eared Bat on the Townsend RD of the Helena NF. Overall, adult males were captured more often than females where we sampled bats (Table 2), a bias that has been noted elsewhere in Montana (Worthington 1991a, 1991b, Hendricks et al. 2000, 2004). It is possible males outnumber females throughout the landscape, but the bias towards males in capture samples could also be a result of differential habitat use by the sexes (Bogan et al. 1996, Cryan et al. 2000) or differences in capture probabilities. Because niche segregation of the sexes is a possibility, information on differences in habitat use by males and females is necessary for monitoring bat populations, developing conservation plans for Species of Concern (e.g., Pierson et al. 1999), and effectively managing landscapes for bats.

In particular, the 2005 survey identified numerous areas where bats are concentrating their activity while seeking food and water resources. Some of these sites may be useful in the future for monitoring efforts across Forest Districts, especially sites that were used by several bat species (see Appendix B). Thus, the 2005 survey was a valuable exercise as a pilot effort in the development of a comprehensive survey and monitoring scheme, both for the Northern Region and all of Montana.

Analysis of Protocols

The largest failure of the 2005 survey was the inadequate use of, and facility with, acoustic technology and analysis. Acoustic technology has great potential to provide rapid assessment of species distributions over many sites and identify areas of significant concentrations of species and individuals. It also has an advantage over capture methods in requiring far less commitment of time and personnel. It is important, however, to have equipment available and field crews trained in the use of this technology well in advance of field surveys. Keeping electronic equipment functional in the field also requires special effort. We consider acoustic monitoring an important component of future inventory and monitoring schemes, but it does not replace capture methods. There remains a need for recorded calls from individuals whose identity is definitive through morphologic and genetic measurement in order to build a library of reference calls for individual species from across the state. The three sets of data (acoustic, morphologic, genetic) will provide future workers using acoustic monitoring the reference tools they need to identify, and correct for, regional differences in calls.

The protocol we used in 2005 called for deployment of mist-nets for 3.5 hours after twilight, weather permitting, or until 1 hour had passed without acoustic detections. The numbers of nets deployed, and the total duration of their deployment, were left to the discretion of field crews. The numbers of nets deployed at sites in 2005 ranged from 2-16, and hours of deployment after twilight ranged from 2 to 7.5. This resulted in large variation in survey effort among sites, and demands on crews varied correspondingly. What level of effort is worth the expense in time and energy of the field crews, and does the extra level of effort result in additional species documented (the primary objective of the 2005 survey)?

The total amount of time all nets are deployed can be used to calculate net-hours, which is a measure of sampling effort. There was large variability in number of species captured and net-hours of effort in 2005, with up to seven species captured in as few as 15 net-hours or as many as 62.5 net-hours (Figure 1). In general, however, the number of species captured during a single night increased with increased sampling effort (Spearman r = 0.580, $P < 0.0001$, n = 50). The relationship appears to be curvilinear, with an asymptote at about 40-50 net-hours, suggesting this level of sampling intensity could represent the best balance between trapping effort and the time and energy commitment of the crew to capture new species.

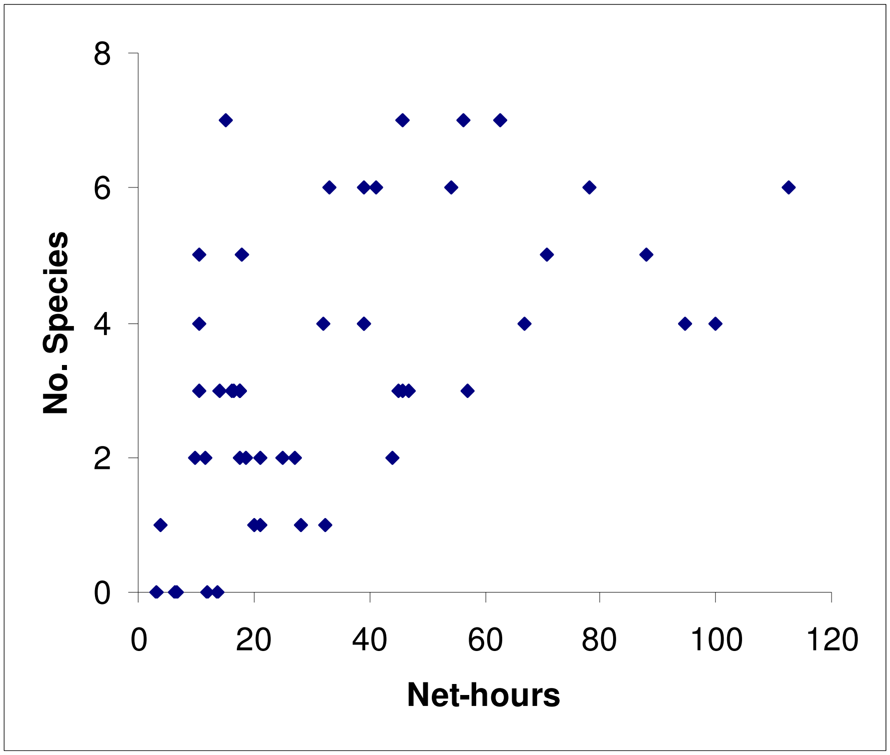

Figure 1. Total sampling effort (net-hours) at each site (n = 50 sites) and the number of species captured. Net-hours = (number of nets deployed x minutes deployed) ÷ 60.

However, for 21 sites where 4-7 species were captured, the number of nets deployed ranged from 3-16, with only 23-80% (mean = 48%) of deployed nets capturing bats; the Oregon Bat Grid protocols recommend use of up to three nets, using a multi-visit approach for surveying sampling units. The maximum number of species captured at 62% of these sites occurred by 40 net-hours, with a mean effort of 29.6 net-hours to reach the full species list at these 21 sites; the full species list of the netting session occurred a mean of 2.6 hours after nets were opened.

A more useful sampling protocol for a broad-scale bat inventory, such as that initiated in 2005, would converge with that used in the Oregon Bat Grid, which incorporates elements of a typical state bird atlas project to help guide the sampling effort applied to each sample unit. In the Oregon scheme, the primary objective is to document all species on a list of expected species generated for each sample unit. Each sample unit is surveyed using multiple detection methods, as we attempted to do in 2005, but also is visited as many times (up to 12) as it takes to achieve the species richness goal, rather than limiting the survey effort to two visits, as was done in 2005. Even for roost monitoring of a species like Townsend's Big-eared Bat, there is so much detection variability during any single visit (due to a variety of environmental and sampling variables) that as many as nine visits to a site may be necessary to identify a non-roost (Sherwin et al. 2003). Although the 2005 survey filled distribution gaps and generated much useful data, limited human and monetary resources kept the survey from achieving the objective of determining species richness for most sample units visited. This failure greatly limits or prohibits the ability to infer sample unit occupancy across Districts.

Conclusions and Recommendations

Knowledge of bats in Montana remains largely based on distribution records (e.g., Nicholson 1950, Hoffmann et al. 1969, Swenson 1970, Swenson and Bent 1977, Swenson and Shanks 1979, Shryer and Flath 1980, Foresman 2001), although there are a few published studies focusing on other aspects of the biology of Montana bats (e.g., Jones et al. 1973, Hendricks et al. 2000). In addition, several agency-funded projects have addressed information gaps that help guide management activities at the BLM Field Office or USFS Ranger District landscape scale (e.g., Worthington 1991a, 1991b, Hendricks and Kampwerth 2001, Hendricks et al. 2004, 2005). Nevertheless, there are no studies from Montana addressing how bats use forested landscapes of different stand types, ages, and structural complexity (e.g., Thomas 1988, Kalcounis et al. 1999). These significant gaps in our understanding of bat use of Montana landscapes remain a major barrier to implementing effective conservation measures.

The modification of landscapes is often considered the major cause of population fluctuations of many bat species. Measures for the conservation of bats frequently rely on knowledge of species-habitat relationships, and the use of distribution maps are often used to assess a species status. Thus, a thorough knowledge of bat distributions as they relate to habitat features is critical for implementing management and conservation actions. However, intensive population surveys of bats are difficult to conduct because of the nocturnal behavior of bats, their large home ranges, and difficulty of species identification while in flight. The latter problem is being addressed with improved acoustic and radio transmitter technology, but intensive population surveys may remain beyond the scope of most conservation/management programs.

Modeling landscape features used by bats offers an alternative approach to multi-species population monitoring that may be useful for bat conservation at a landscape scale (Jaberg and Guisan 2001). To do modeling effectively, however, a large base of distribution records is necessary that sample all species and account for all activities (foraging, roosting, rearing young, mating, hibernating). This may be difficult to do across a landscape the size of Montana, but a systematic and standard method of data collection across the state will make habitat modeling a more realistic possibility.

Need for a Montana Bat Grid

Montana currently lacks any statewide scheme for bat inventory and monitoring. This will be a crucial component for effective implementation of the state bat conservation plan now under development. The objectives of a state bat grid are 1) to inventory the presence of bat species using a standardized survey effort and sampling unit across the survey region, 2) collect baseline data on acoustic, morphologic, and genetic characteristics that serve as reference for bat species identification, and 3) to provide a baseline assessment of site occupany rates in order to identify changes in status over time. Inventorying and monitoring bat distributions and trends at this scale will place us in a better position to address conservation issues as they arise. To date, none of these objectives has been thoroughly addressed in Montana.

We recommend the development of a bat grid that is applied to all of Montana. Simply determining whether or not a species is present or breeding in a grid cell is a valuable way of monitoring the distribution and status of species over time and relative to a variety of associated variables (Hayek 1994; Olson et al. 1997). The Oregon Bat Grid offers a suitable model scheme from which to design a state bat grid, although modification of some protocols may be necessary for application to Montana, due to limitations in personnel and agency support, as well as land access issues.

It is beyond the scope of this report to explore the details of what comprises a state bat grid. Nevertheless, the scheme that is eventually developed should include a hierarchical scale of data collection, stratified by ecoregion and/or Ranger District, that allows inference of grid cell occupancy rates. To infer occupany rates, it is necessary to determine detection probabilities, and to do this will require multiple surveys of a subset of sites in each stratum. Strength of inference is very limited with regard to the status of a population in any single grid cell using only the data on presence/non-detection, and may best be regarded as being informative relative to management actions at broader spatial scales. However, this is also an approach for raising red flags at individual habitat patches or local regions (and grid cells) so that these rapid assessment surveys can be followed up with more detailed studies of a populations' status.

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APPENDIX A. GLOBAL/STATE RANK DEFINITIONS

Heritage Program Ranks

The international network of Natural Heritage Programs employs a standardized ranking system to denote global (range-wide) and state status. Species are assigned numeric ranks ranging from 1 to 5, reflecting the relative degree to which they are "at-risk". Rank definitions are given below. A number of factors are considered in assigning ranks — the number, size and distribution of known "occurrences" or populations, population trends (if known), habitat sensitivity, and threat. Factors in a species' life history that make it especially vulnerable are also considered (e.g., dependence on a specific pollinator).

Global Rank Definitions (NatureServe 2003)

G1	Critically imperiled because of extreme rarity and/or other factors making it highly vulnerable to extinction
G2	Imperiled because of rarity and/or other factors making it vulnerable to extinction
G3	Vulnerable because of rarity or restricted range and/or other factors, even though it may be abundant at some of its locations
G4	Apparently secure, though it may be quite rare in parts of its range, especially at the periphery
G5	Demonstrably secure, though it may be quite rare in parts of its range, especially at the periphery
T1-5	**Infraspecific Taxon** (trinomial) —The status of infraspecific taxa (subspecies or varieties) are indicated by a "T-rank" following the species' global rank

State Rank Definitions

S1	At high risk because of extremely limited and potentially declining numbers, extent and/or habitat, making it highly vulnerable to extirpation in the state
S2	At risk because of very limited and potentially declining numbers, extent and/or habitat, making it vulnerable to extirpation in the state
S3	Potentially at risk because of limited and potentially declining numbers, extent and/or habitat, even though it may be abundant in some areas
S4	Uncommon but not rare (although it may be rare in parts of its range), and usually widespread. Apparently not vulnerable in most of its range, but possibly cause for long-term concern
S5	Common, widespread, and abundant (although it may be rare in parts of its range). Not vulnerable in most of its range

Combination Ranks

G#G# or S#S#	**Range Rank**—A numeric range rank (e.g., G2G3) used to indicate uncertainty about the exact status of a taxon

Qualifiers

NR	Not ranked
Q	**Questionable taxonomy that may reduce conservation priority**—Distinctiveness of this entity as a taxon at the current level is questionable; resolution of this uncertainty may result in change from a species to a subspecies or hybrid, or inclusion of this taxon in another taxon, with the resulting taxon having a lower-priority (numerically higher) conservation status rank

X	**Presumed Extinct**—Species believed to be extinct throughout its range. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered
H	**Possibly Extinct**—Species known from only historical occurrences, but may never-the-less still be extant; further searching needed
U	**Unrankable**—Species currently unrankable due to lack of information or due to substantially conflicting information about status or trends
HYB	**Hybrid**—Entity not ranked because it represents an interspecific hybrid and not a species
?	**Inexact Numeric Rank**—Denotes inexact numeric rank
C	**Captive or Cultivated Only**—Species at present is extant only in captivity or cultivation, or as a reintroduced population not yet established
A	**Accidental**—Species is accidental or casual in Montana, in other words, infrequent and outside usual range. Includes species (usually birds or butterflies) recorded once or only a few times at a location. A few of these species may have bred on the one or two occasions they were recorded
Z	**Zero Occurrences**—Species is present but lacking practical conservation concern in Montana because there are no definable occurrences, although the taxon is native and appears regularly in Montana
P	**Potential**—Potential that species occurs in Montana but no extant or historic occurrences are accepted
R	**Reported**—Species reported in Montana but without a basis for either accepting or rejecting the report, or the report not yet reviewed locally. Some of these are very recent discoveries for which the program has not yet received first-hand information; others are old, obscure reports
SYN	**Synonym**—Species reported as occurring in Montana, but the Montana Natural Heritage Program does not recognize the taxon; therefore the species is not assigned a rank
*	A rank has been assigned and is under review. Contact the Montana Natural Heritage Program for assigned rank
B	**Breeding**—Rank refers to the breeding population of the species in Montana
N	**Nonbreeding**—Rank refers to the non-breeding population of the species in Montana

Appendix B. USFS Region 1 Montana Survey Sites for Bats, Summer 2005

Forest[a]	County	UTM NAD 27	Site Name	Elev (ft)	Date	Bats Captured[b]
Flathead	Lake	(12) 290574E; 5284745N	Van Lake Road	3560	7 Jul	no captures; LACI (seen)
Flathead	Lake	(12) 287845E; 5282522N	Piper Creek	3540	19 Jul	MYCA (1), MYLU (2), MYVO (1)
Flathead	Lake	(12) 277184E; 5316885N	Crane Creek	5030	20 Jul	MYCA (1), MYVO (5)
Flathead	Lake	(12) 277315E; 5318840N (12) 723502E; 5319317N	498 Pond, Phillips Trail Creek	4760 4160	21 Jul 21 Jul	MYEV (1) MYCA (1), MYLU (1)
Flathead	Lake	(12) 287613E; 5312939N	Swan Lake Campground	3170	8 Aug	MYLU (5), MYVO (1)
Flathead	Lake	(12) 287850E; 5314746N	Upper Hall Creek	4160	9 Aug	MYEV (1)
Flathead	Missoula	(12) 295676E; 5254290N	Upper Swan River	4210	15 Aug	no captures
Flathead	Missoula	(12) 293522E; 5259389N	Glacier Creek	4140	16 Aug	MYCA (1), MYEV (1), MYLU (3), MYVO (2)
Flathead	Missoula	(12) 297270E; 5269803N	Lower Smith Creek	3840	17 Aug	no captures
Flathead	Missoula	(12) 302307E; 5263977N	Buck Creek	4440	18 Aug	no captures
Gallatin	Gallatin	(12) 503510E; 5034206N	Window Rock	6790	26 Jul	MYLU (1)
Gallatin	Gallatin	(12) 487455E; 5030963N	Rat Lake Road	5840	27 Jul	EPFU (4), LACI (16), LANO (10), MYLU (3)
Gallatin	Gallatin	(12) 491290E; 5040200N	Cliff Creek	5980	28 Jul	LANO (1), MYLU (2)
Gallatin	Gallatin	(12) 482598E; 5031782N	Squaw Creek	5442	29 Jul	LACI (1), MYLU (1), MYVO (1)
Gallatin	Gallatin	(12) 495785E; 5028440N	Butte Meadow	6990	30 Jul	EPFU (6), LACI (5), LANO (5), MYEV (13), MYLU (4), MYVO (7)
Gallatin	Gallatin	(12) 493549E; 5023581N	Swan Creek South Fork	6763	31 Jul	MYEV (4), MYLU (3), MYVO (1)
Gallatin	Gallatin	(12) 481392E; 5007561N	Porcupine Creek	6178	1 Aug	LANO (10), MYEV (1), MYLU (1)

[a] Sites were on a single District for each Forest surveyed: Flathead-Swan Lake RD, Gallatin-Bozeman RD, Helena-Townsend RD, Kootenai-Libby RD, Lewis & Clark-Judith RD.

[b] species codes: COTO (*Corynorhinus townsendii*, Townsend's Big-eared Bat), EPFU (*Eptesicus fuscus*, Big Brown Bat), LACI (*Lasiurus cinereus*, Hoary Bat), LANO (*Lasionycteris noctivagans*), MYCA (*Myotis californicus*, California Myotis), MYCI (*Myotis ciliolabrum*, Western Small-footed Myotis), MYEV (*Myotis evotis*, Western Long-eared Myotis), MYLU (*Myotis lucifugus*, Little Brown Myotis), MYTH (*Myotis thysanodes*, Fringed Myotis), MYVO (*Myotis volans*, Long-legged Myotis), MYYU (*Myotis yumanensis*, Yuma Myotis).

Forest[a]	County	UTM NAD 27	Site Name	Elev (ft)	Date	Bats Captured[b]
Gallatin	Gallatin	(12) 486790E; 498616N	Snowflake Spring	6671	3 Aug	EPFU (1), LANO (6), MYCI (1), MYLU (17)
Gallatin	Gallatin	(12) 503150E; 5083477N	Fairy Lake	7642	4 Aug	EPFU (2), LACI (4), MYEV (2), MYLU (104)
Gallatin	Gallatin	(12) 495804E; 5090761N	Pass Creek	5766	5 Aug	LACI (4), LANO (1), MYEV (12), MYLU (40), MYVO (7)
Helena	Broadwater	(12) 461167E; 5162045N	White Gulch	4533	24 Jun	LANO (1), MYEV (3)
Helena	Broadwater	(12) 485585E; 5128083N	Sulphur Bar Creek	5220	25 Jun	MYEV (1)
Helena	Broadwater	(12) 470340E; 5161514N	Confederate-Blacktail Cabins	5206	27 Jun	LANO (1), MYEV (1), MYLU (2)
Helena	Lewis and Clark	(12) 454662E; 5166689N	Hellgate Gulch	4576	28 Jun	COTO (1), MYCI (1), MYEV (2), MYLU (5), MYTH (1), MYVO (2), MYYU (1)
Helena	Broadwater	(12) 456081E; 5165595N	Hand Stencil Cave	4670	29 Jun	COTO (8), EPFU (1), MYCI (10), MYEV (1), MYLU (3), MYTH (3), MYVO (2)
Helena	Broadwater	(12) 446696E; 5121569N	Slim Sam Creek	5005	30 Jun	EPFU (2), LACI (1), LANO (1), MYCI (3), MYEV (2), MYVO (1)
Helena	Broadwater	(12) 442452E; 5128251N	Crow Creek	5239	1 Jul	LACI (2), MYVO (3)
Helena	Broadwater	(12) 482016E; 5154203N	Camas Creek	5815	22 Jul	MYEV (1)
Helena	Broadwater	(12) 477184E; 5155593N	Camas Lake	7384	23 Jul	no captures

[a] Sites were on a single District for each Forest surveyed: Flathead-Swan Lake RD, Gallatin-Bozeman RD, Helena-Townsend RD, Kootenai-Libby RD, Lewis & Clark-Judith RD.

[b] species codes: COTO (*Corynorhinus townsendii*, Townsend's Big-eared Bat), EPFU (*Eptesicus fuscus*, Big Brown Bat), LACI (*Lasiurus cinereus*, Hoary Bat), LANO (*Lasionycteris noctivagans*), MYCA (*Myotis californicus*, California Myotis), MYCI (*Myotis ciliolabrum*, Western Small-footed Myotis), MYEV (*Myotis evotis*, Western Long-eared Myotis), MYLU (*Myotis lucifugus*, Little Brown Myotis), MYTH (*Myotis thysanodes*, Fringed Myotis), MYVO (*Myotis volans*, Long-legged Myotis), MYYU (*Myotis yumanensis*, Yuma Myotis).

Forest[a]	County	UTM NAD 27	Site Name	Elev (ft)	Date	Bats Captured[b]
Helena	Broadwater	(12) 485185E; 5129996N	Deep Creek Campground	4848	6 Aug	EPFU (1), LACI (7), LANO (19), MYEV (6), MYLU (2), MYVO (5)
Kootenai	Lincoln	(11) 632719E; 5377231N	Fivemile	2460	12 Jul	LANO (1), MYCA (1), MYLU (1)
Kootenai	Lincoln	(11) 625650E; 5374561N	Barron Creek Meadow	2550	13 Jul	LACI (seen), MYCA (3)
Kootenai	Lincoln	(11) 595251E; 5366860N	Bighorn Terrace	1990	14 Jul	EPFU (2), MYLU (18)
Kootenai	Lincoln	(11) 599468E; 5373080N	Quartz Creek	2920	15 Jul	LACI (1), LANO (2), MYLU (1)
Kootenai	Lincoln	(11) 608118E; 5351145N	Granite Creek	2470	25 Jul	LACI (1), MYLU (3)
Kootenai	Lincoln	(11) 601822E; 5349892N	Granite Creek Trailhead	3000	26 Jul	MYEV (5), MYTH (1), MYVO (1)
Kootenai	Lincoln	(11) 618729E; 5332611N	Road 6740L Pothole	4250	27 Jul	LACI (seen), LANO (6), MYCA (2), MYEV (1), MYVO (2)
Kootenai	Lincoln	(11) 617100E; 5326445N	Miller Creek	3100	28 Jul	EPFU (3), LACI (3), LANO (1), MYCA (3), MYEV (1), MYLU (1), MYYU (1)
Kootenai	Lincoln	(11) 612500E; 5321408N	Lake Creek Campground	3450	10 Aug	LANO (1), MYCA (1), MYLU (5)
Kootenai	Lincoln	(11) 608663E; 5322887N	Fisher Creek	3720	11 Aug	MYLU (4), MYTH (1), MYVO (1)
Lewis & Clark	Judith Basin	(12) 543578E; 5176352N	Russian Creek Beaver Ponds	6596	11 Jul	LANO (1), MYLU (1)

[a] Sites were on a single District for each Forest surveyed: Flathead-Swan Lake RD, Gallatin-Bozeman RD, Helena-Townsend RD, Kootenai-Libby RD, Lewis & Clark-Judith RD.

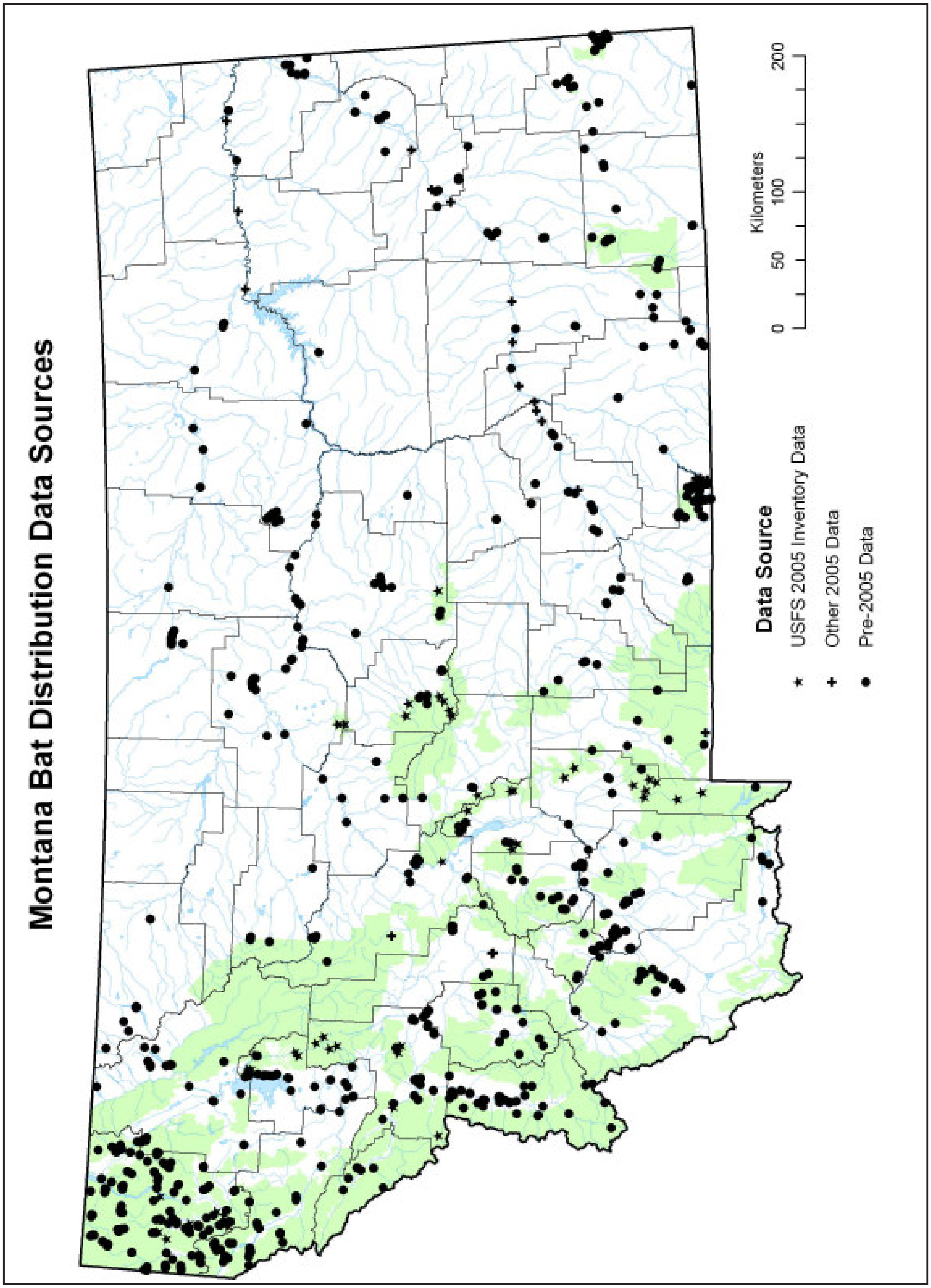
[b] species codes: COTO (*Corynorhinus townsendii*, Townsend's Big-eared Bat), EPFU (*Eptesicus fuscus*, Big Brown Bat), LACI (*Lasiurus cinereus*, Hoary Bat), LANO (*Lasionycteris noctivagans*), MYCA (*Myotis californicus*, California Myotis), MYCI (*Myotis ciliolabrum*, Western Small-footed Myotis), MYEV (*Myotis evotis*, Western Long-eared Myotis), MYLU (*Myotis lucifugus*, Little Brown Myotis), MYTH (*Myotis thysanodes*, Fringed Myotis), MYVO (*Myotis volans*, Long-legged Myotis), MYYU (*Myotis yumanensis*, Yuma Myotis).

Forest[a]	County	UTM NAD 27	Site Name	Elev (ft)	Date	Bats Captured[b]
Lewis & Clark	Judith Basin	(12) 550065E; 5180585	Hay Canyon	5663	12 Jul	LACI (3), LANO (3), MYCI (3), MYEV (2)
Lewis & Clark	Fergus	(12) 613523E; 5184384N	Crystal Lake	6044	13 Jul	EPFU (3), LACI (8), LANO (1), MYEV (7), MYLU (33), MYVO (3)
Lewis & Clark	Fergus	(12) 631433E; 5185926N	Half Moon Canyon	5727	14 Jul	EPFU (19), LACI (4), LANO (11), MYEV (2), MYLU (1), MYVO (10)
Lewis & Clark	Judith Basin	(12) 539092E; 5208119N	Dry Wolf Creek	5735	15 Jul	EPFU (6), LACI (8), LANO (10), MYCI (1), MYEV (2), MYVO (6)
Lewis & Clark	Judith Basin	(12) 547835E; 5206111N	Running Wolf	5215	17 Jul	LACI (1), LANO (7), MYCI (1), MYLU (1), MYVO (3)
Lewis & Clark	Chouteau	(12) 531831E; 5252920N	Big Coulee	5069	18 Jul	LACI (4), LANO (5), MYEV (1), MYVO (1)
Lewis & Clark	Chouteau	(12) 531676E; 5257969N	Thain Creek Campground	4590	19 Jul	LACI (7), LANO (56), MYEV (1), MYLU (5), MYVO (1)
Lewis & Clark	Judith Basin	(12) 539585E; 5174565N	South Fork Creek	6485	20 Jul	EPFU (2), LACI (2), LANO (12), MYLU (7)
Lewis & Clark	Judith Basin	(12) 553755E; 5183584N	Indian Hill	5136	21 Jul	EPFU (1), LACI (5), LANO (3), MYCI (1), MYEV (1), MYLU (5), MYVO (4)

[a] Sites were on a single District for each Forest surveyed: Flathead-Swan Lake RD, Gallatin-Bozeman RD, Helena-Townsend RD, Kootenai-Libby RD, Lewis & Clark-Judith RD.

[b] species codes: COTO (*Corynorhinus townsendii*, Townsend's Big-eared Bat), EPFU (*Eptesicus fuscus*, Big Brown Bat), LACI (*Lasiurus cinereus*, Hoary Bat), LANO (*Lasionycteris noctivagans*), MYCA (*Myotis californicus*, California Myotis), MYCI (*Myotis ciliolabrum*, Western Small-footed Myotis), MYEV (*Myotis evotis*, Western Long-eared Myotis), MYLU (*Myotis lucifugus*, Little Brown Myotis), MYTH (*Myotis thysanodes*, Fringed Myotis), MYVO (*Myotis volans*, Long-legged Myotis), MYYU (*Myotis yumanensis*, Yuma Myotis).

Appendix C. Distribution Maps for Bats in Montana



Montana Bat Distribution Data Sources
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Other 2005 Data
Pre-2005 Data
Kilometers
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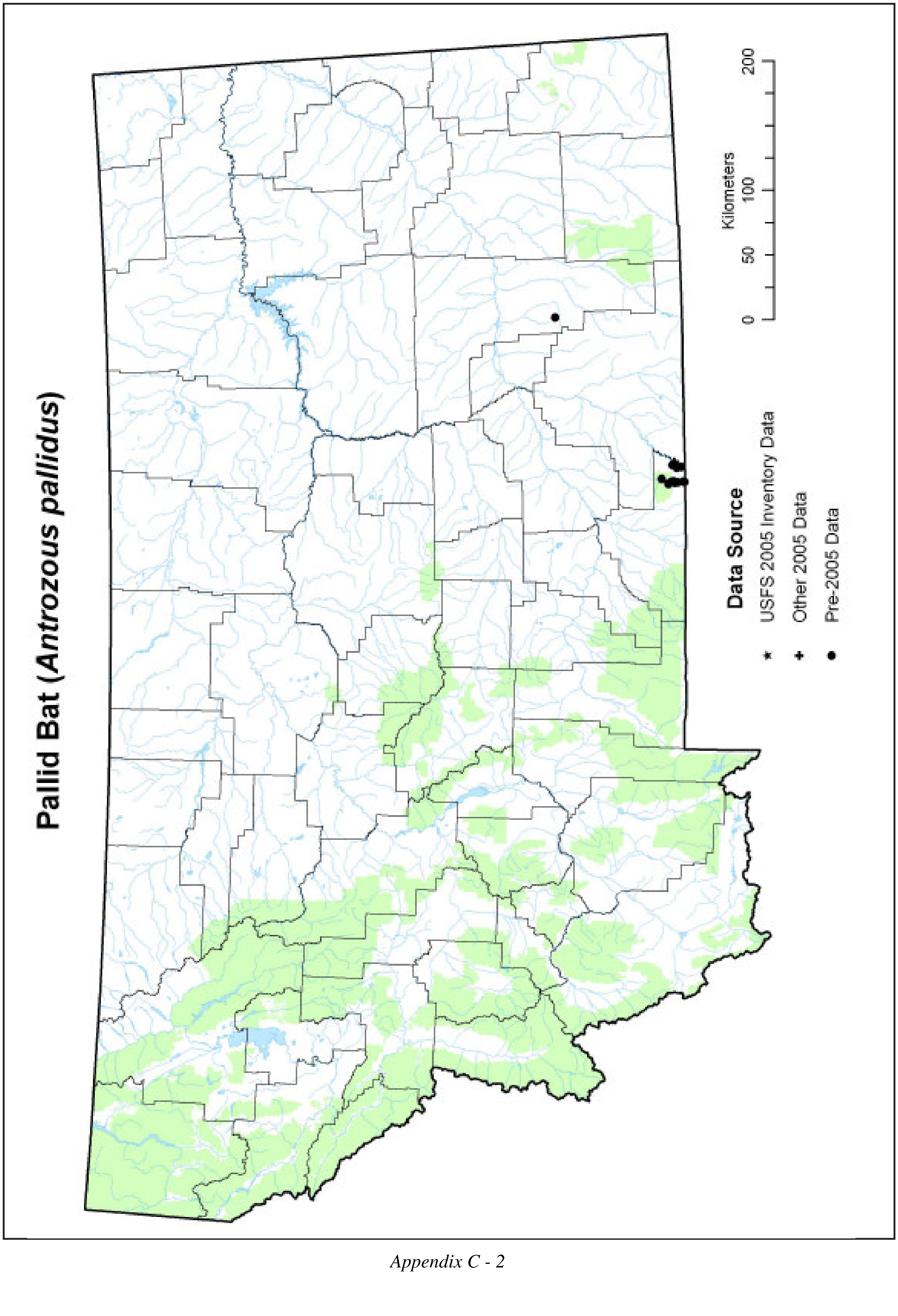
50
100
200



Pallid Bat (Antrozous pallidus)
Data Source
USFS 2005 Inventory Data
Other 2005 Data
Pre-2005 Data
Kilometers
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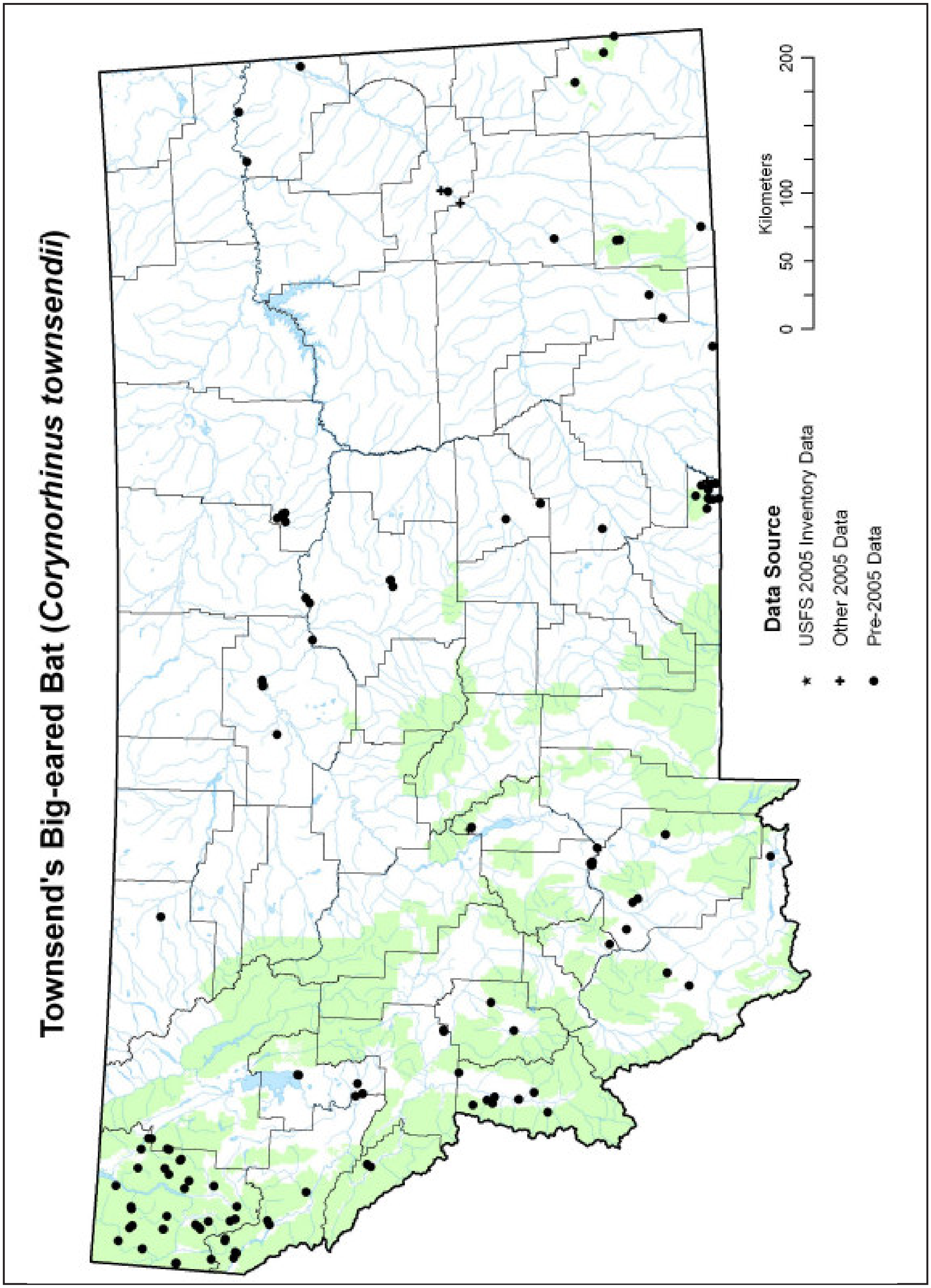
Townsend's Big-eared Bat (Corynorhinus townsendii)
Data Source
USFS 2005 Inventory Data
Other 2005 Data
Pre-2005 Data
Kilometers
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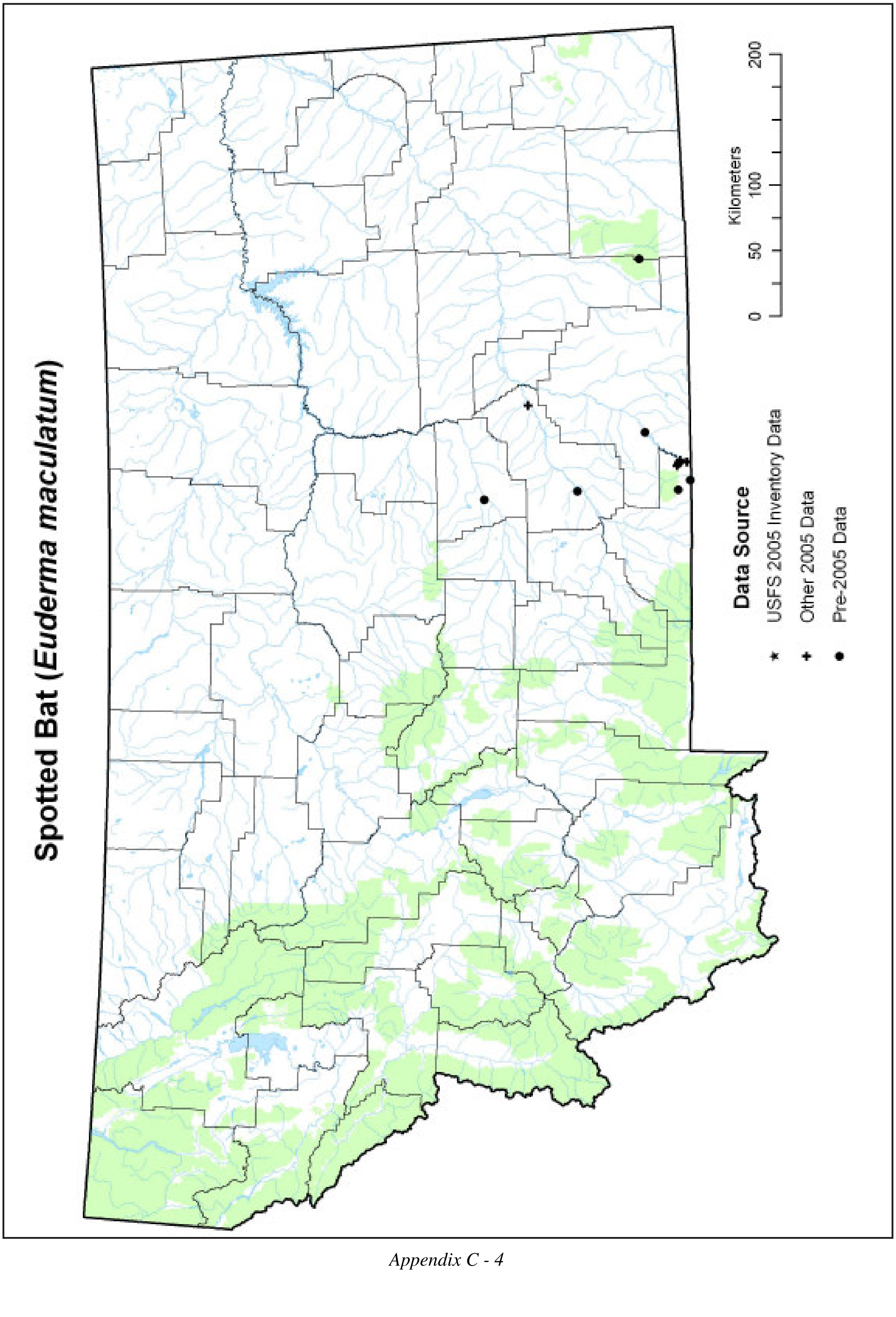
Spotted Bat (Euderma maculatum)
Data Source
USFS 2005 Inventory Data
Other 2005 Data
Pre-2005 Data
Kilometers
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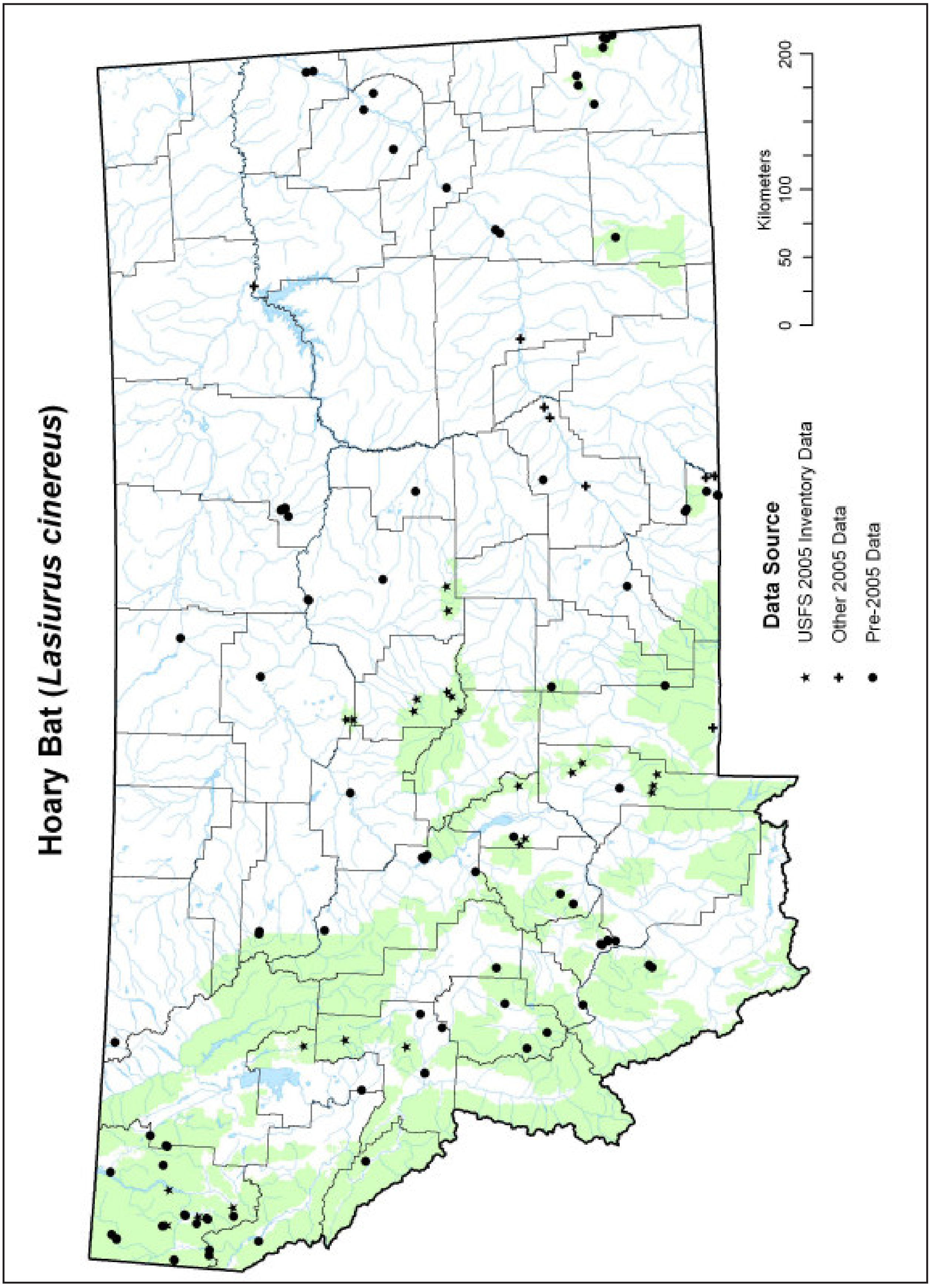
Hoary Bat (Lasiurus cinereus)
Data Source
USFS 2005 Inventory Data
Other 2005 Data
Pre-2005 Data
Kilometers
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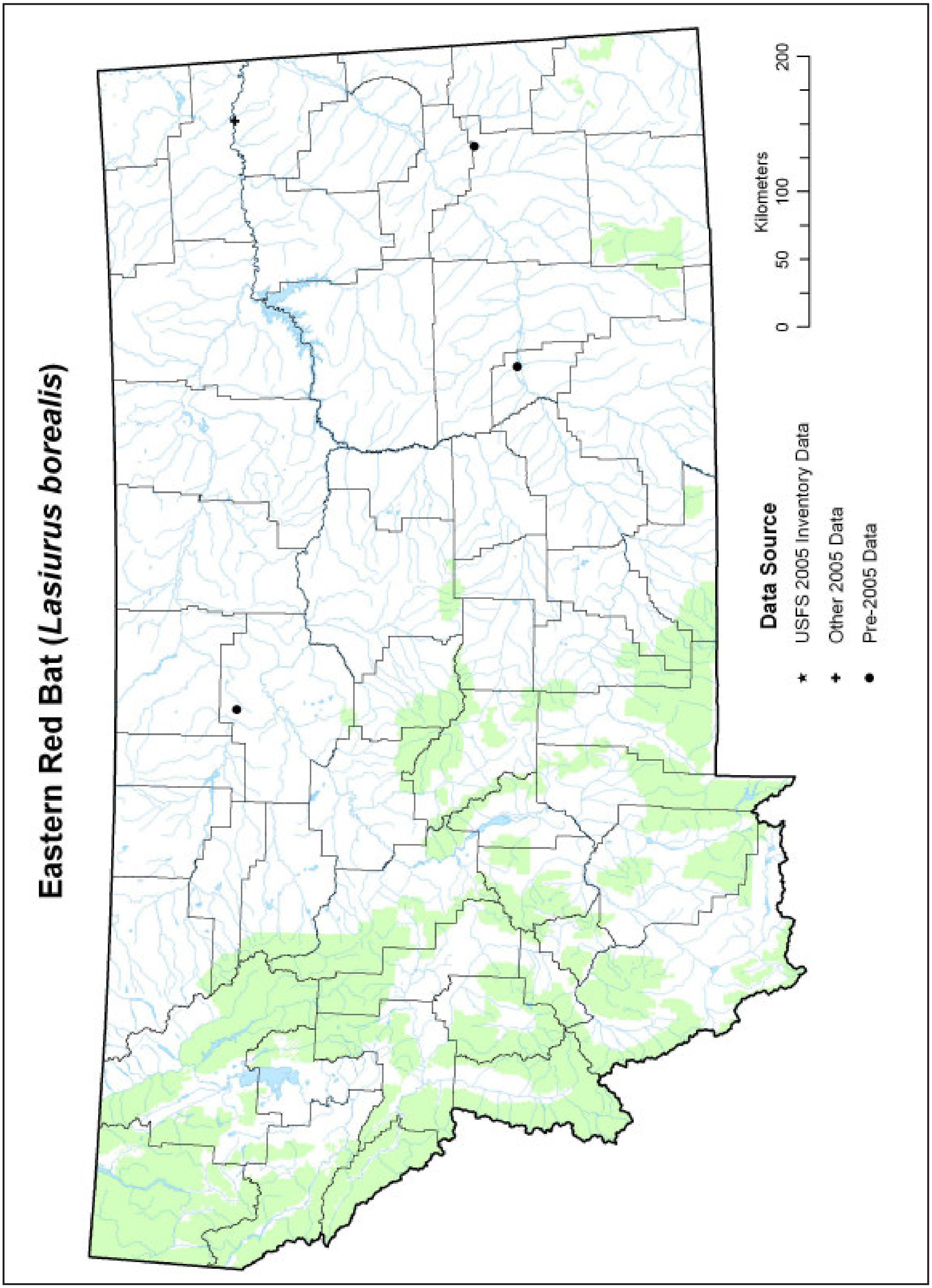
Eastern Red Bat (*Lasiurus borealis*)
Data Source
USFS 2005 Inventory Data
Other 2005 Data
Pre-2005 Data
Kilometers
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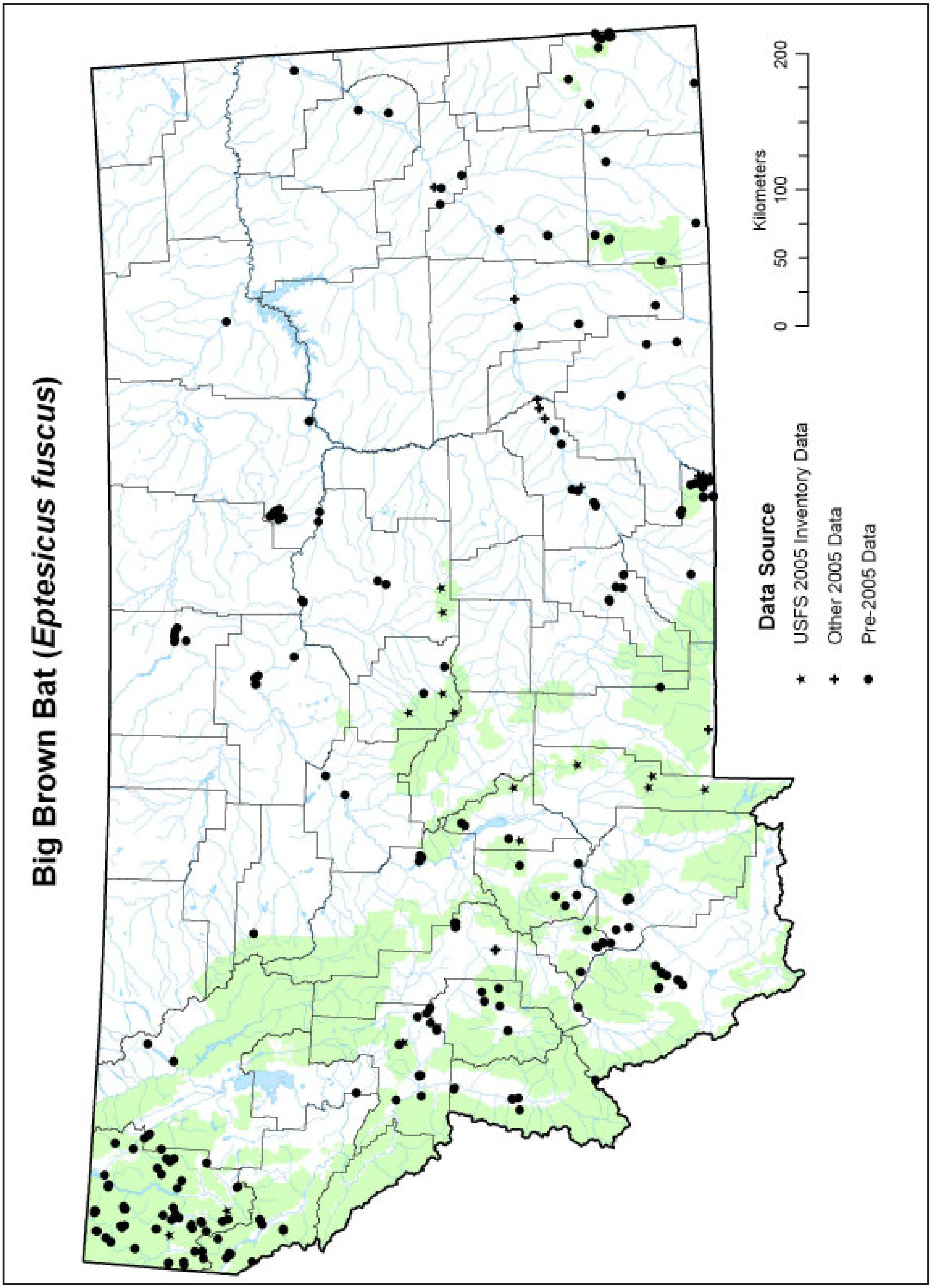
Big Brown Bat (*Eptesicus fuscus*)
Data Source
USFS 2005 Inventory Data
Other 2005 Data
Pre-2005 Data
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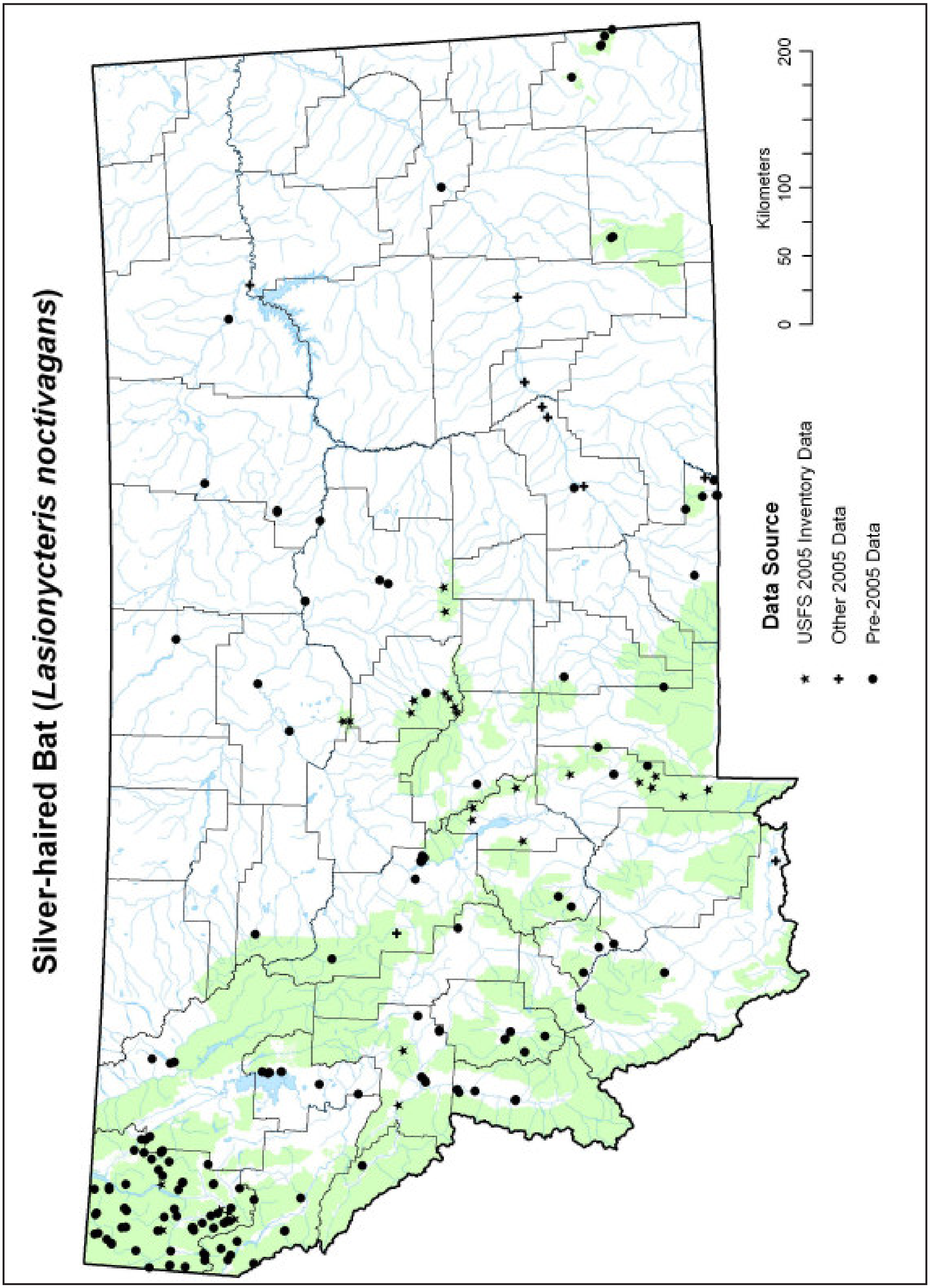
Kilometers


Silver-haired Bat (Lasionycteris noctivagans)
Data Source
USFS 2005 Inventory Data
Other 2005 Data
Pre-2005 Data
Kilometers
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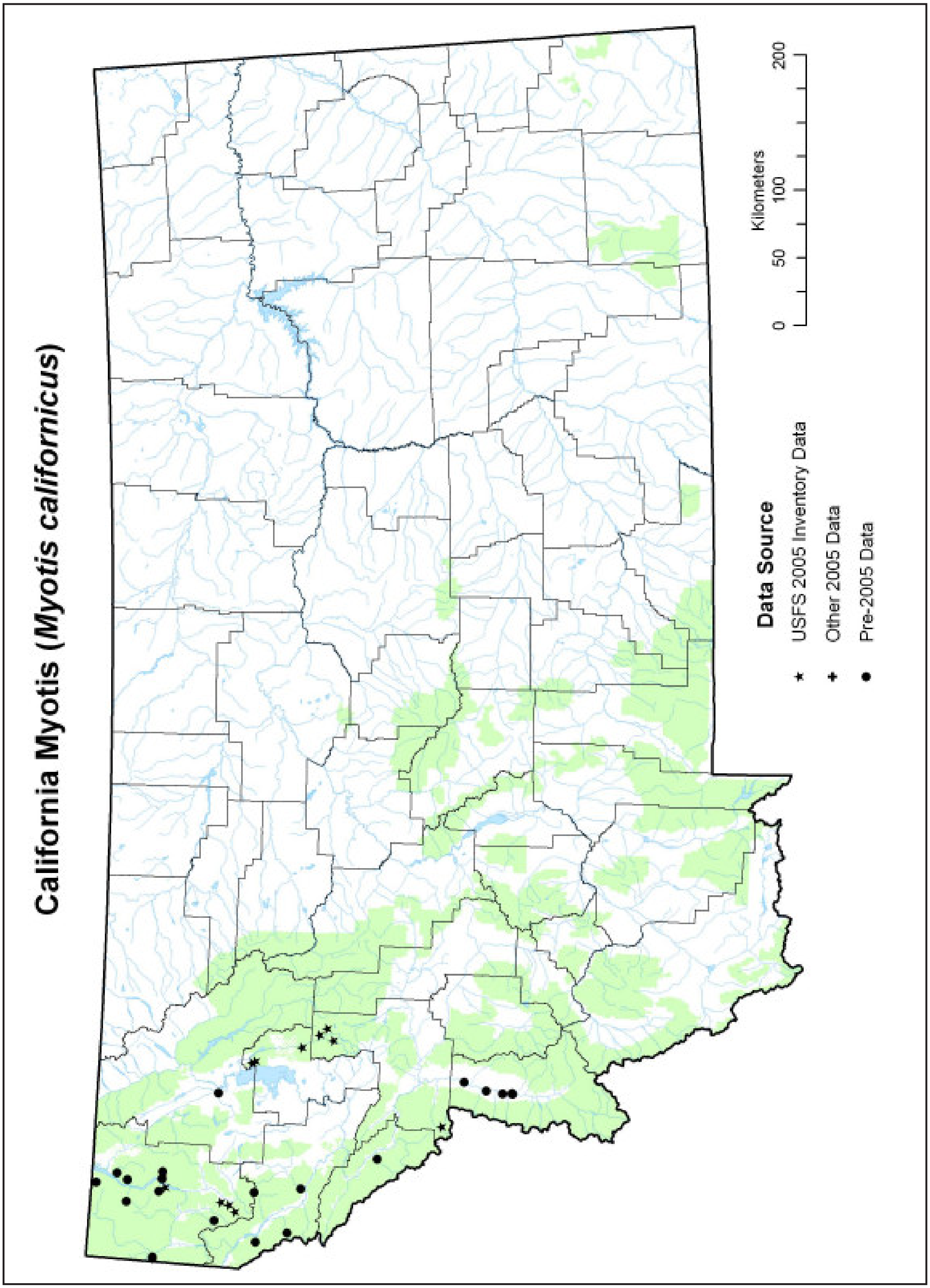
California Myotis (Myotis californicus)
Data Source
USFS 2005 Inventory Data
Other 2005 Data
Pre-2005 Data
Kilometers
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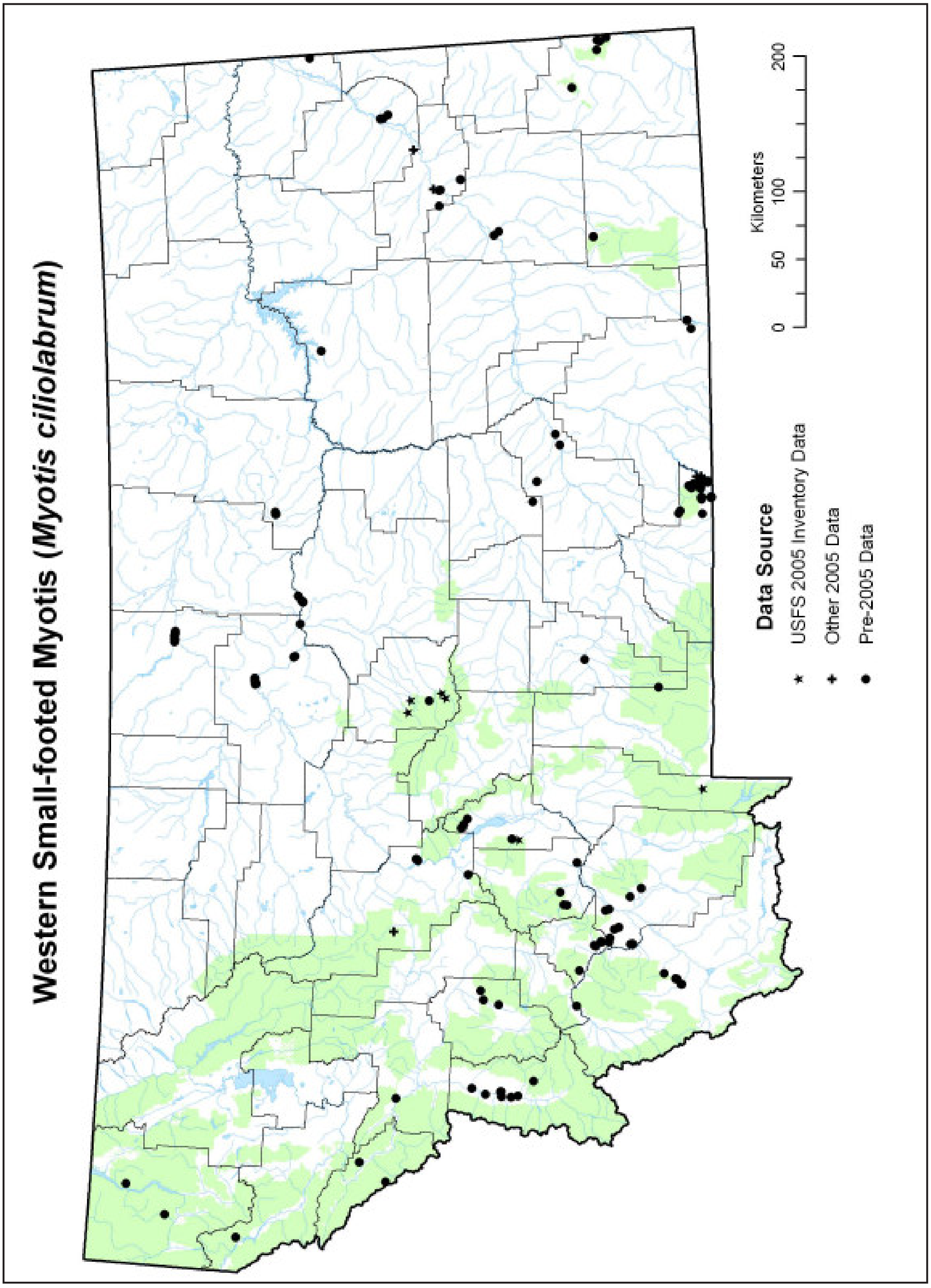
Western Small-footed Myotis (*Myotis ciliolabrum*)
Kilometers
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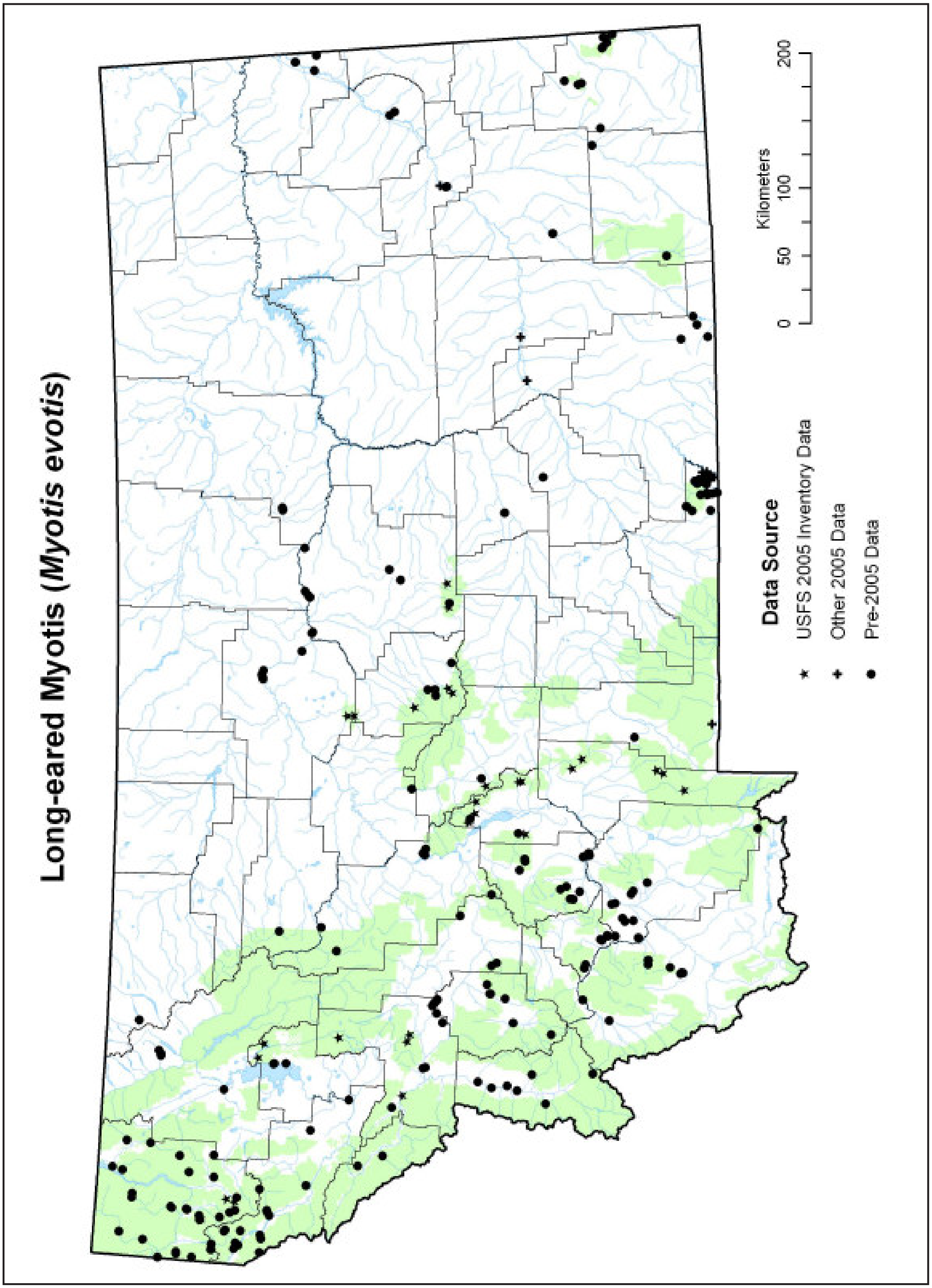
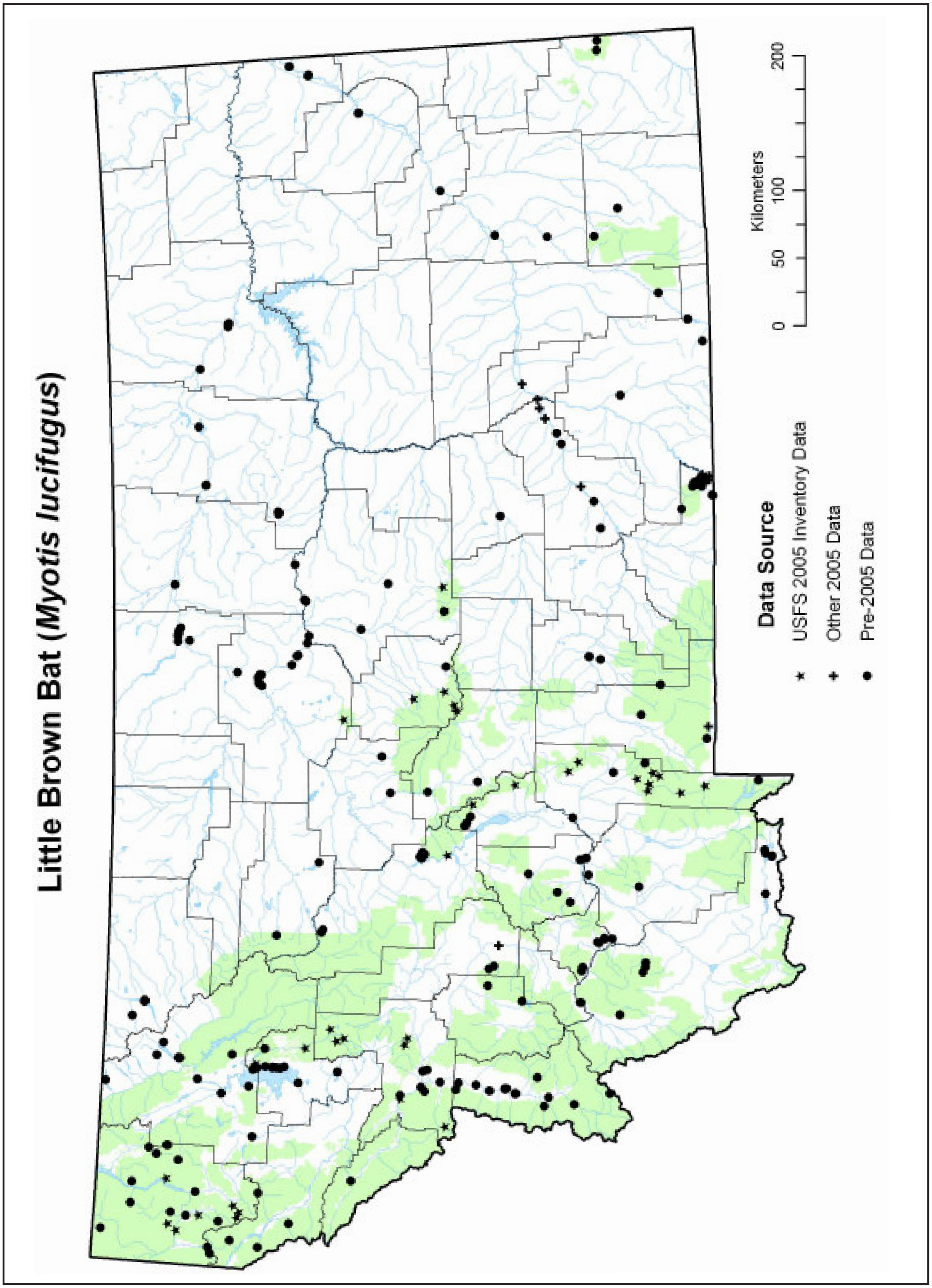
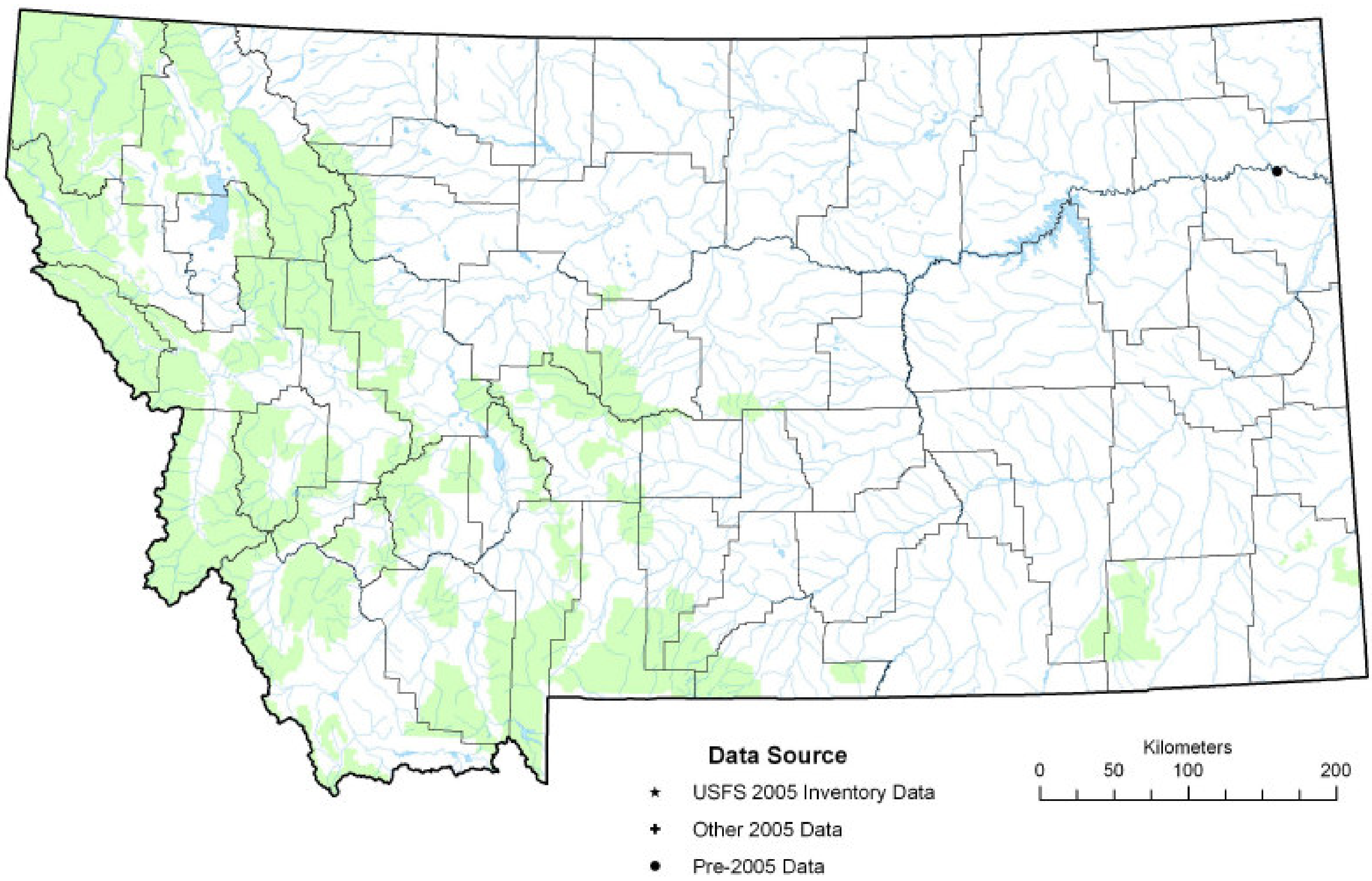
Data Source
USFS 2005 Inventory Data
Other 2005 Data
Pre-2005 Data

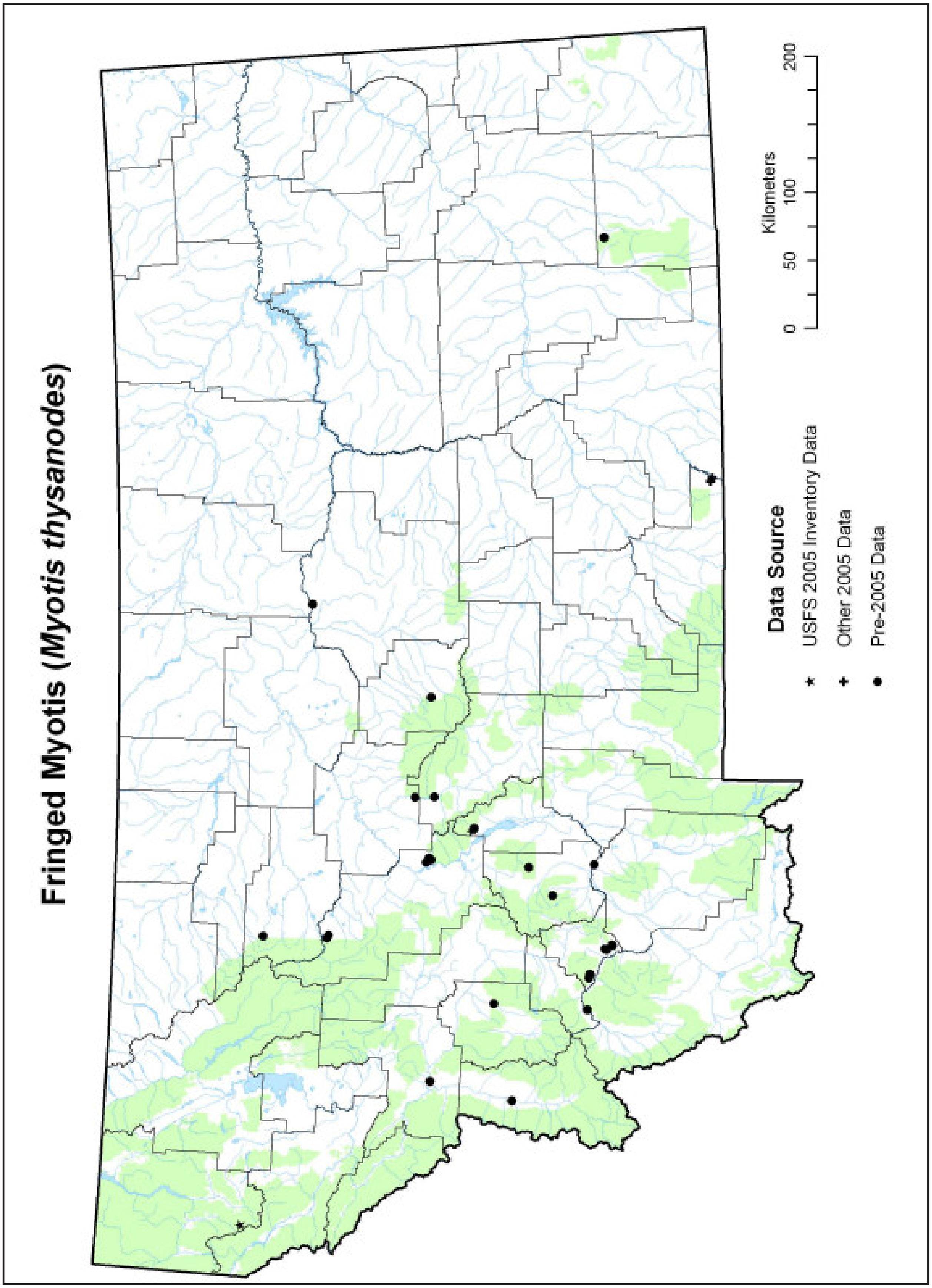


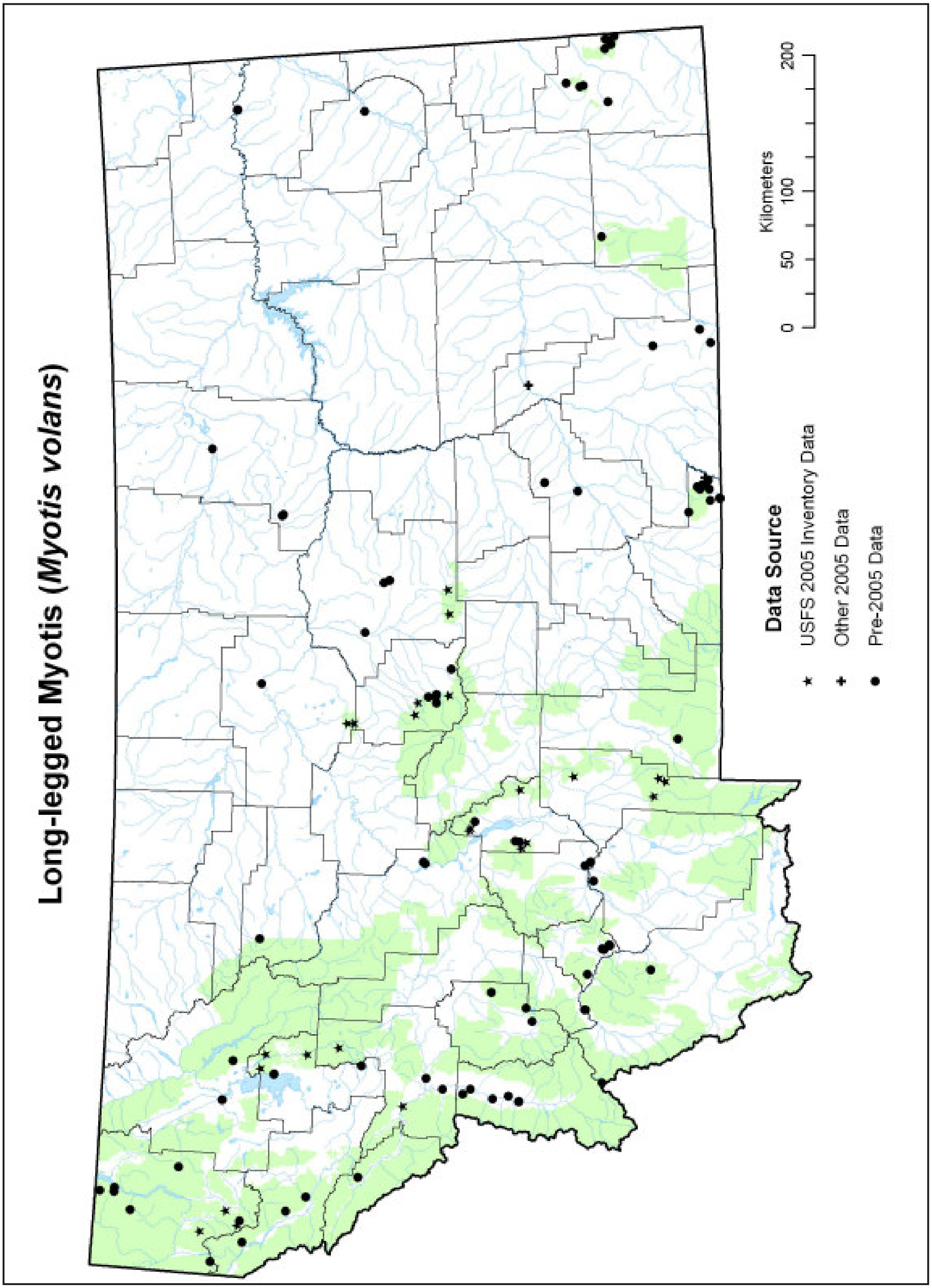
Long-eared Myotis (*Myotis evotis*)


Little Brown Bat (Myotis lucifugus)
Data Source
USFS 2005 Inventory Data
Other 2005 Data
Pre-2005 Data
Kilometers
0
50
100
200

Northern Myotis (*Myotis septentrionalis*)




Fringed Myotis (*Myotis thysanodes*)
Data Source
USFS 2005 Inventory Data
Other 2005 Data
Pre-2005 Data
Kilometers
0
50
100
200



Long-legged Myotis (*Myotis volans*)
Data Source
USFS 2005 Inventory Data
Other 2005 Data
Pre-2005 Data
Kilometers
0
50
100
200

Yuma myotis (*Myotis yumanensis*)